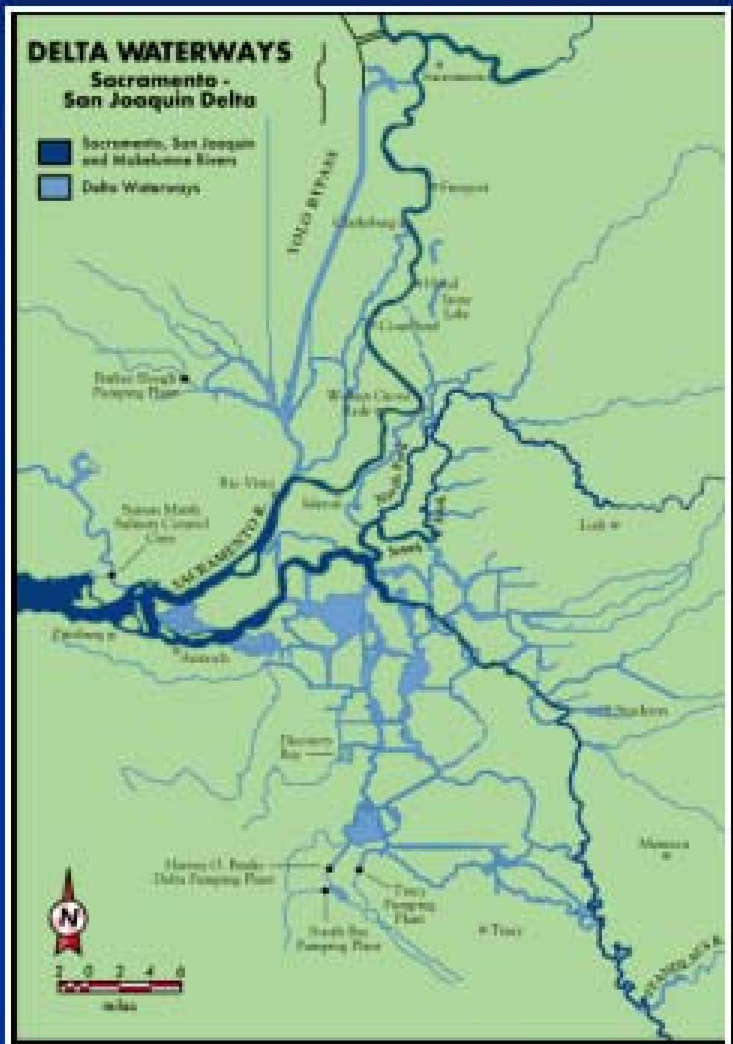
Subsidence, Seismicity and Sea Level Rise: Hell AND High Water in the Delta*



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Watershed Center
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** This talk has not been approved by the Independent Science Board and does not represent the views of the Board*

Acknowledgments

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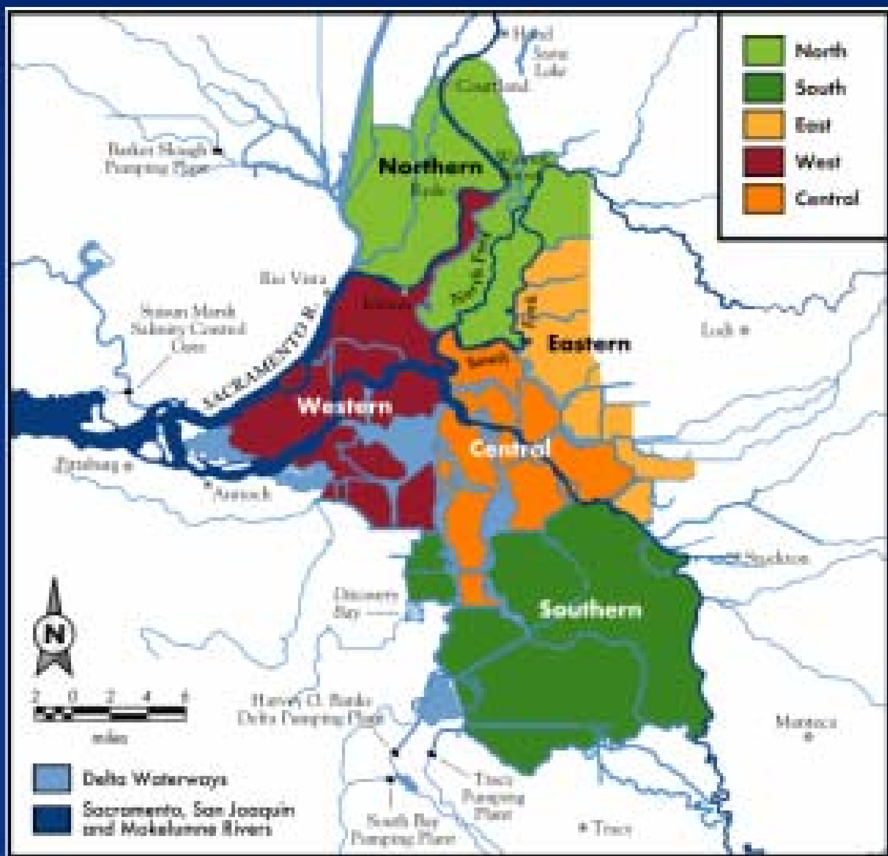
- Resources: **NHI, PWA, NHC** and **USGS**
- Illustrations: **Janice Fong**, UC Davis

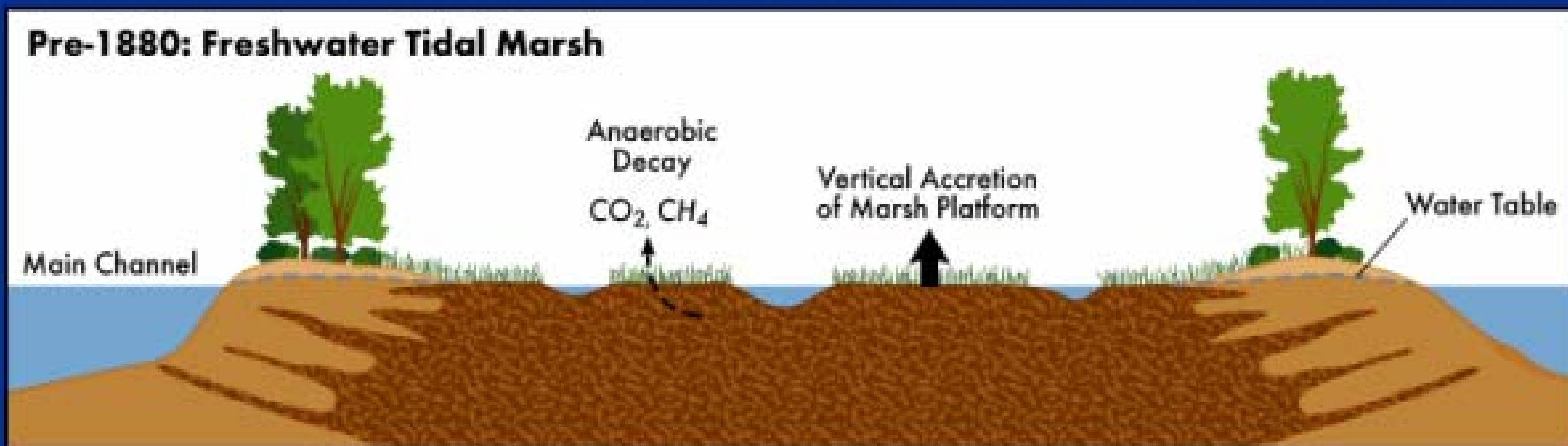
Old News Revisited as a Hypothesis

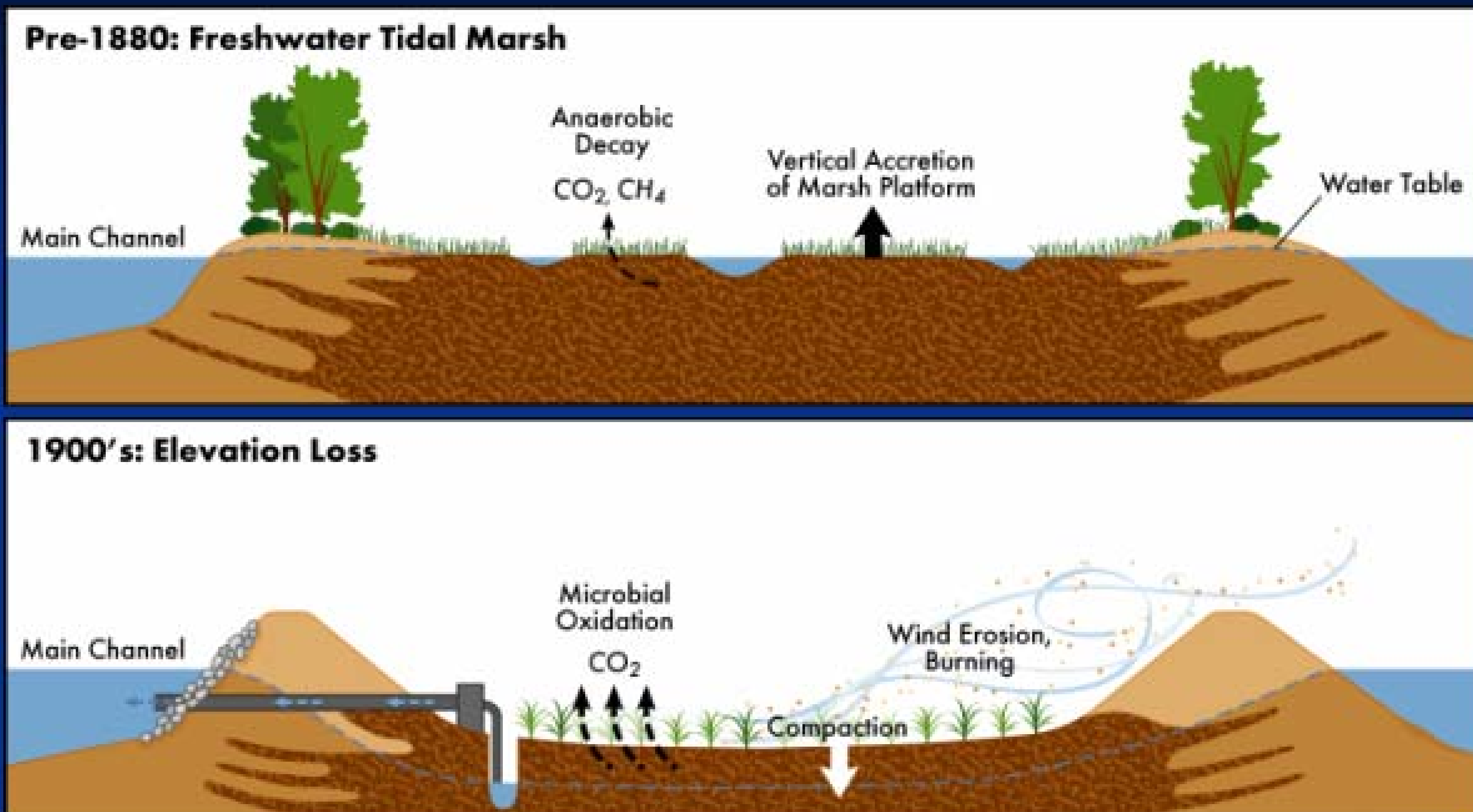
- The Delta is a dynamic landscape undergoing significant change at multiple scales
- Change will be considerable in the future due to continued subsidence and sea level rise
- There is a high probability that abrupt change will take place in the next 50 years
- There is no institutional capacity to respond to dynamic Delta landscapes

Delta Landscape Processes



- Subsidence
- Sea Level
- Seismicity
- Sedimentation
- Climate Change
- Hydrology
- Land Use


Pre-1880: Freshwater Tidal Marsh
Anaerobic Decay
CO_2, CH_4
Vertical Accretion of Marsh Platform
Water Table
Main Channel



Pre-1880: Freshwater Tidal Marsh
Anaerobic Decay
CO_2, CH_4
Vertical Accretion of Marsh Platform
Water Table
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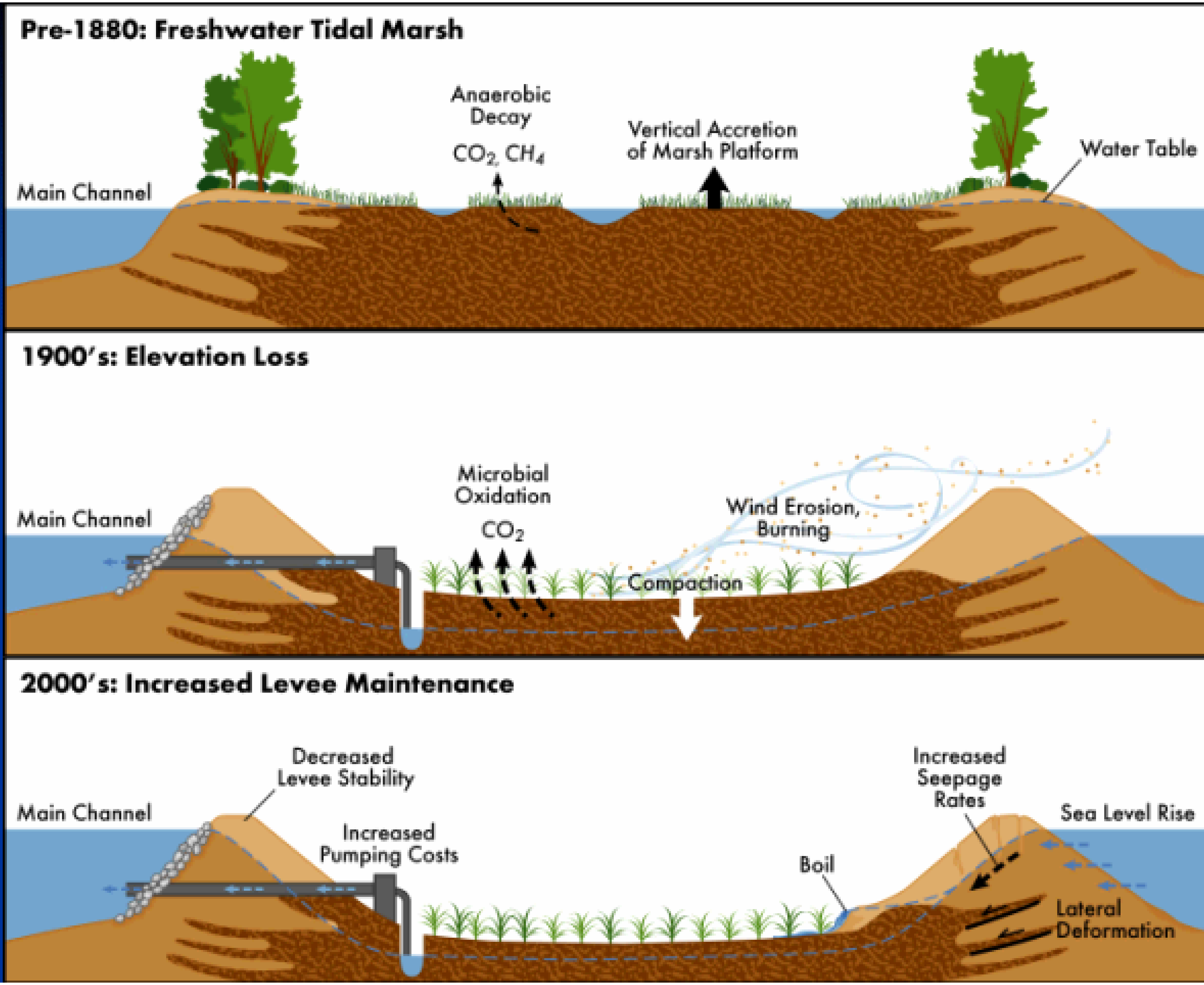
1900's: Elevation Loss
Microbial Oxidation
CO_2
Wind Erosion, Burning
Main Channel
Compaction



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CO_2, CH_4
Vertical Accretion of Marsh Platform
Water Table
Main Channel
1900's: Elevation Loss
Microbial Oxidation
CO_2
Wind Erosion, Burning
Compaction
Main Channel
2000's: Increased Levee Maintenance
Decreased Levee Stability
Main Channel
Increased Pumping Costs
Increased Seepage Rates
Sea Level Rise
Boil
Lateral Deformation

Indices of Change: Potential vs Consequent

- Anthropogenic accommodation space as a proxy for the consequence of landscape change

- Regional hydrostatic force as a proxy for potential levee failure

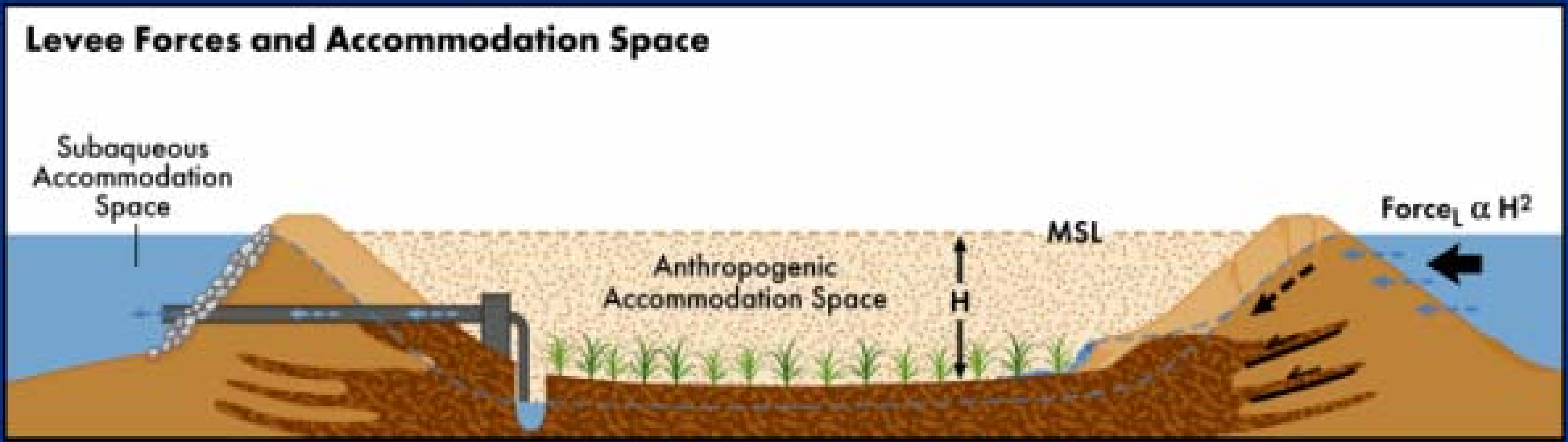
Accommodation Space Index

$$ASI = (A_s + A_a)/A_a$$

Where:

A_s = Anthropogenic Accommodation Space

A_a = Subaqueous Accommodation Space



Levee Force Index

$$LFI = F_t/F_{1900}$$

Where:

F_l = (hydrostatic pressure) x (depth x width) = Force/unit levee length

$F_t = F_l$ x Levee Length

since $F_l = (.5\rho gH)(H \cdot b)$, then

F_t is proportional to H^2

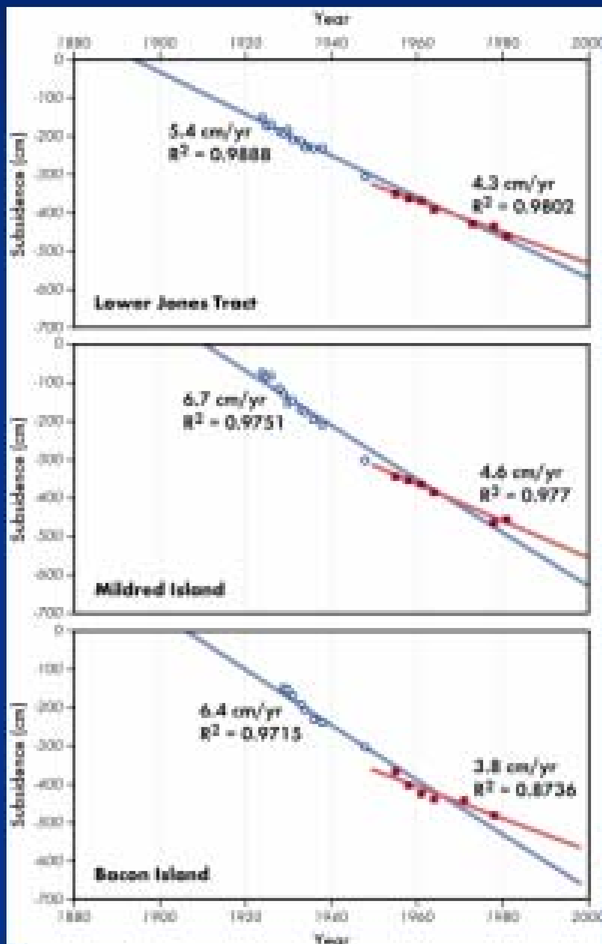
Methods: Data Sources

- Shuttle Radar Topography Mission (SRTM), Feb. 2000
- Research Program in Environmental Planning (REGIS)
- DWR Island data, peat distribution and thickness
- Deverel publications

Methods: Historic Change

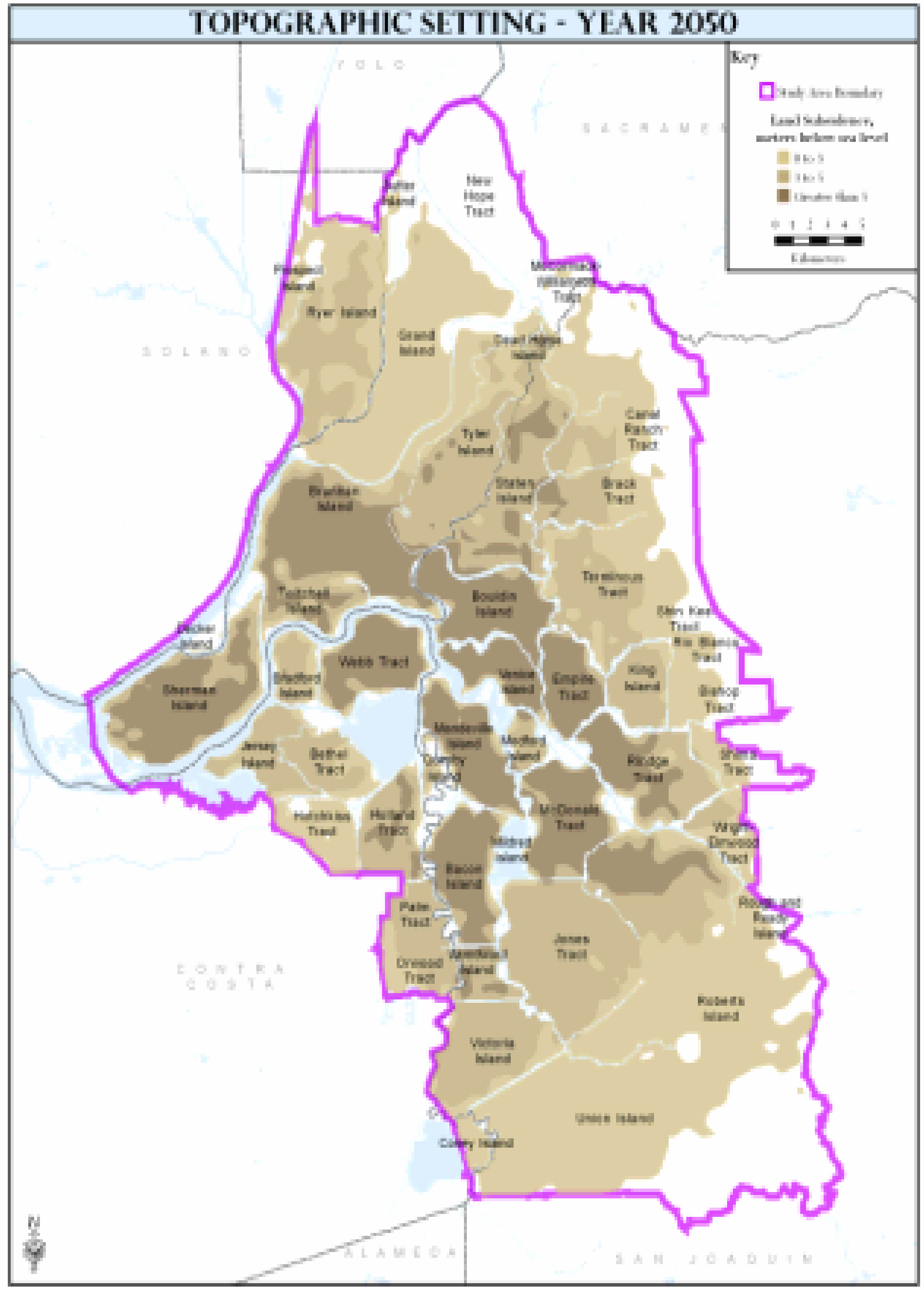
- Zonal statistics to estimate A_a in 2000
- Bathymetric data to estimate A_s
- Estimated average annual accommodation space change for 1900-2000
- Calculated hydrostatic force on each levee segment based on island elevation relative to MSL

Methods: Simulations



- Regressed 1920-1980 and post-1950 data (Deverel data)
- Estimate decline in subsidence rates on peat soils (conservative)
- Factored in IPCC sea level rise by 2050 (conservative)
- Assume business-as-usual conditions, simulated stepwise lowering of islands until base of peat layer encountered


TOPOGRAPHIC SETTING - YEAR 2000
Key
YOLO
SACRAMENTO
SOLANO
CONTRA COSTA
ALAMEDA
SAN JOAQUIN
New Hope Tract
Ryer Island
Grand Island
Dead Horse Island
Tyler Island
Canal Ranch Tract
Staten Island
Brack Tract
Brannan Island
Terminous Tract
Twitchell Island
Bouldin Island
Decker Island
Webb Tract
Sherman Island
Bradford Island
Venice Island
Empire Tract
King Island
Bishop Tract
Jersey Island
Bethel Tract
Mandeville Island
Medford Island
Rindge Tract
McDonald Tract
Hotchkiss Tract
Holland Tract
Mildred Island
Bacon Island
Palm Tract
Jones Tract
Orwood Tract
Roberts Island
Victoria Island
Union Island


TOPOGRAPHIC SETTING - YEAR 2050
Key
YOLO
SACRAMENTO
SOLANO
CONTRA COSTA
ALAMEDA
SAN JOAQUIN
New Hope Tract
Ryer Island
Grand Island
Dead Horse Island
Tyler Island
Canal Ranch Tract
Staten Island
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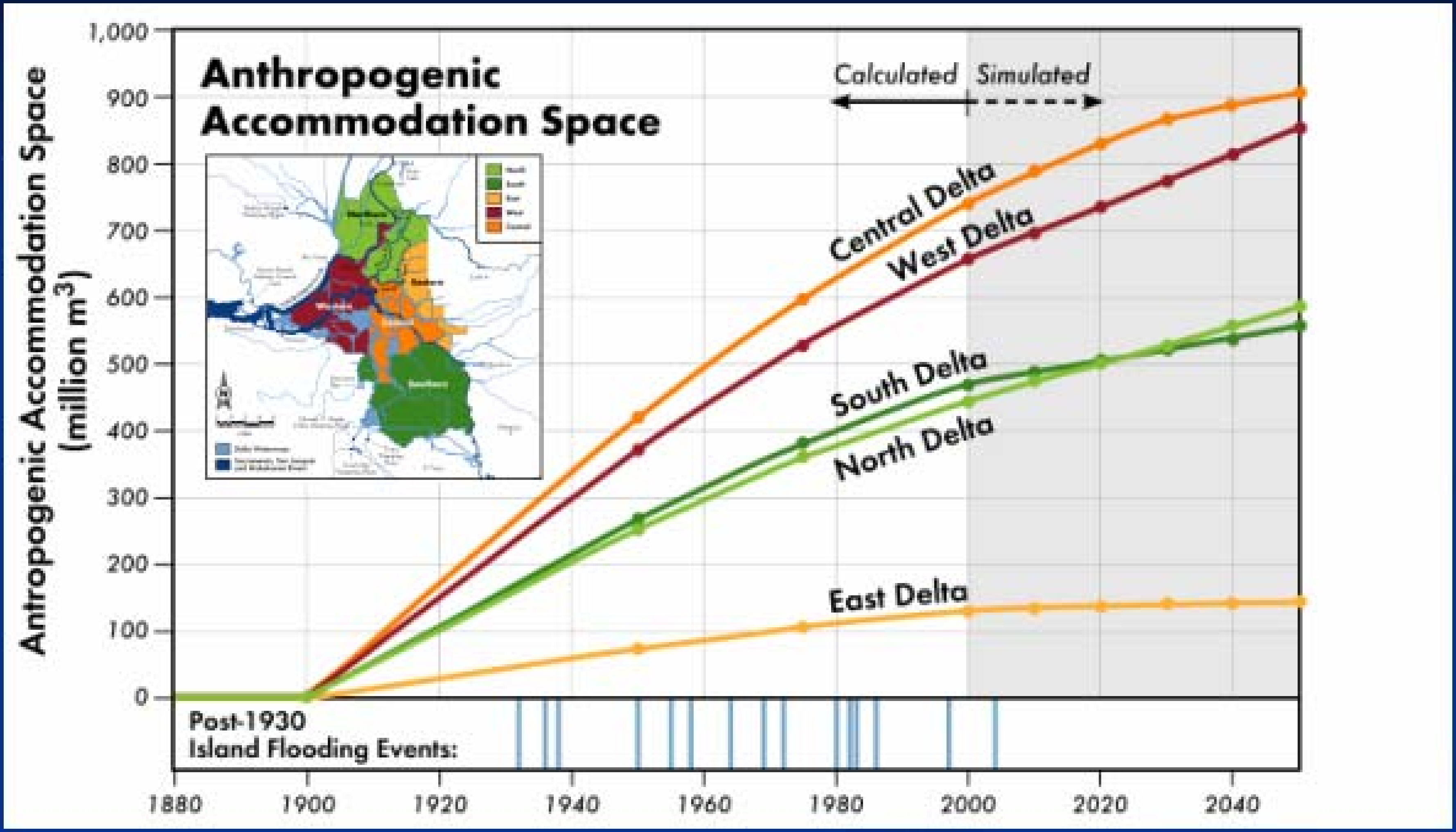
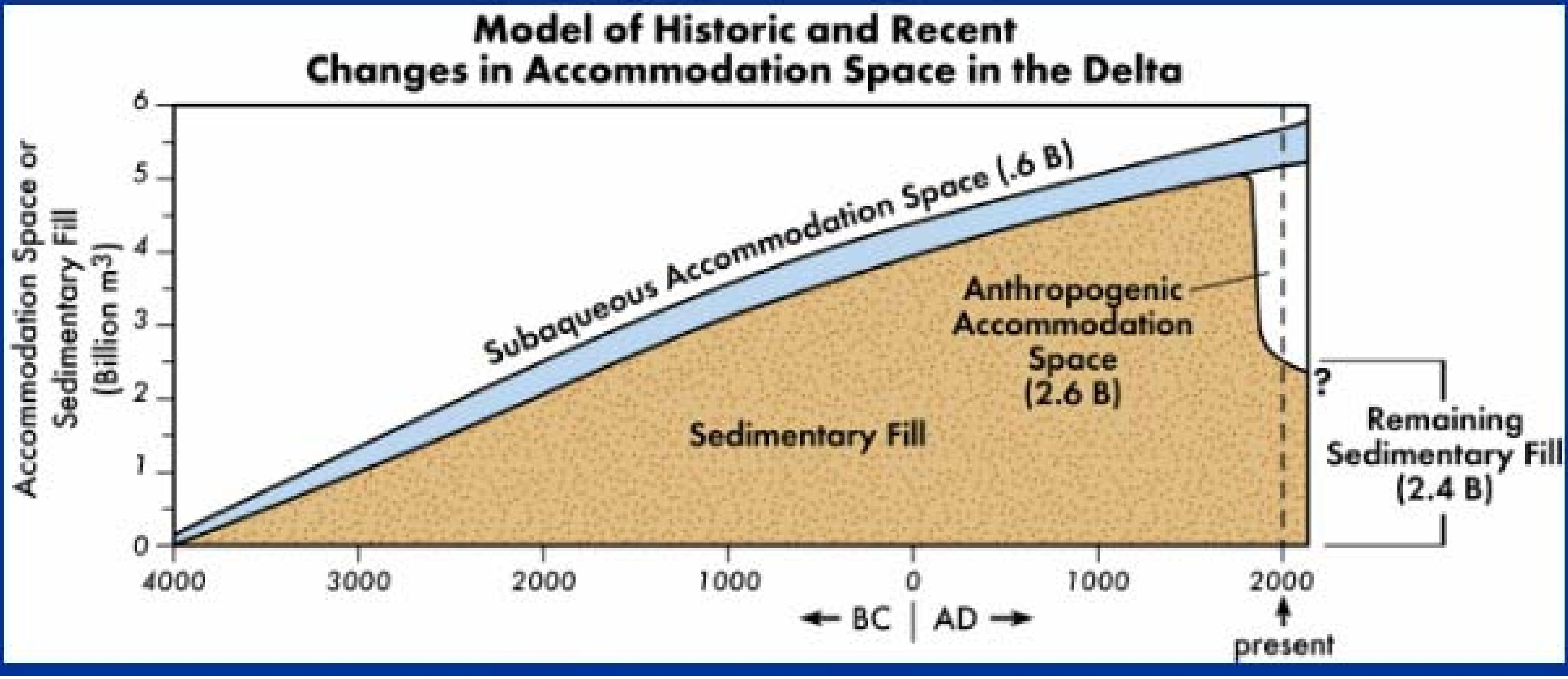
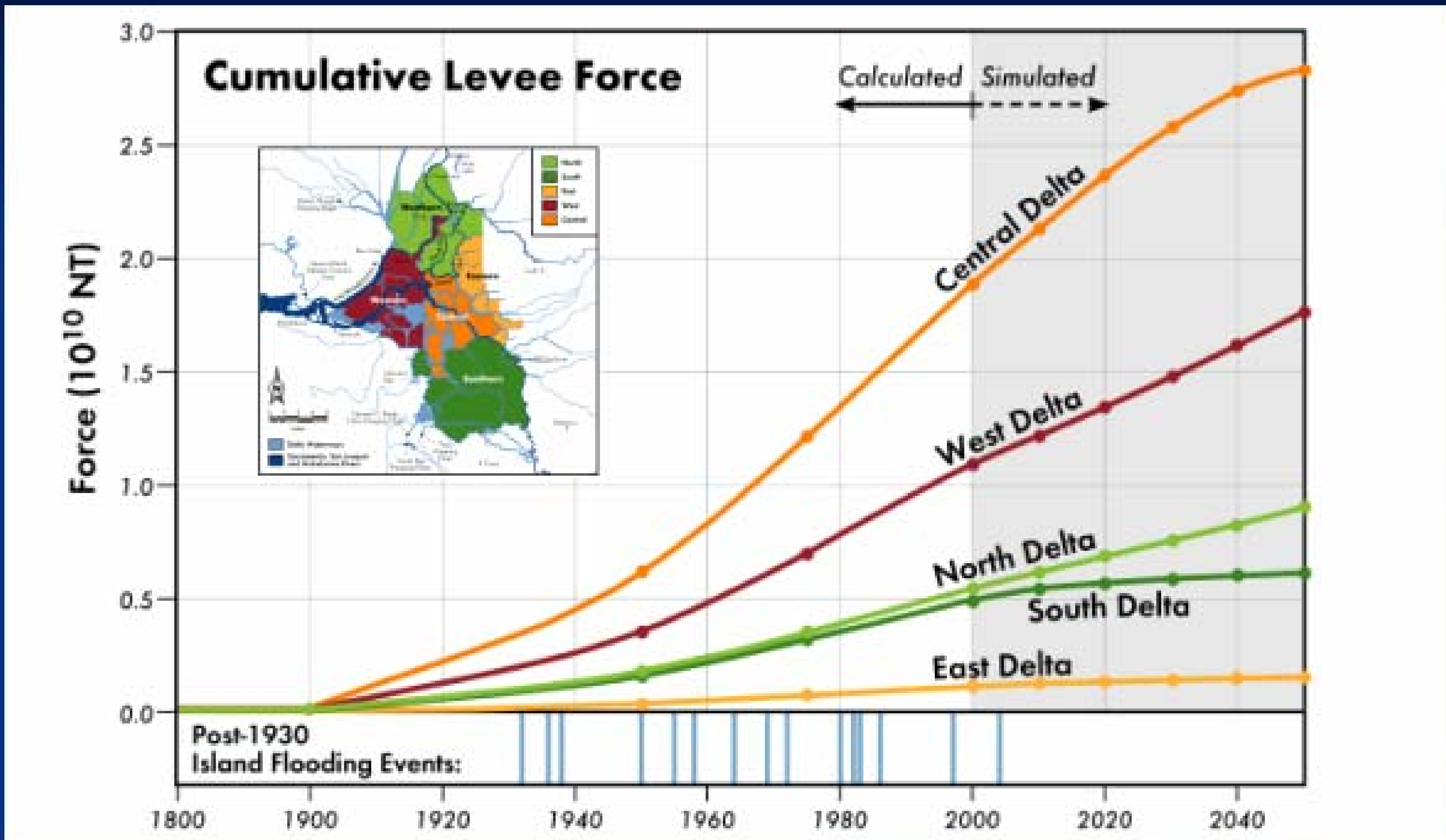


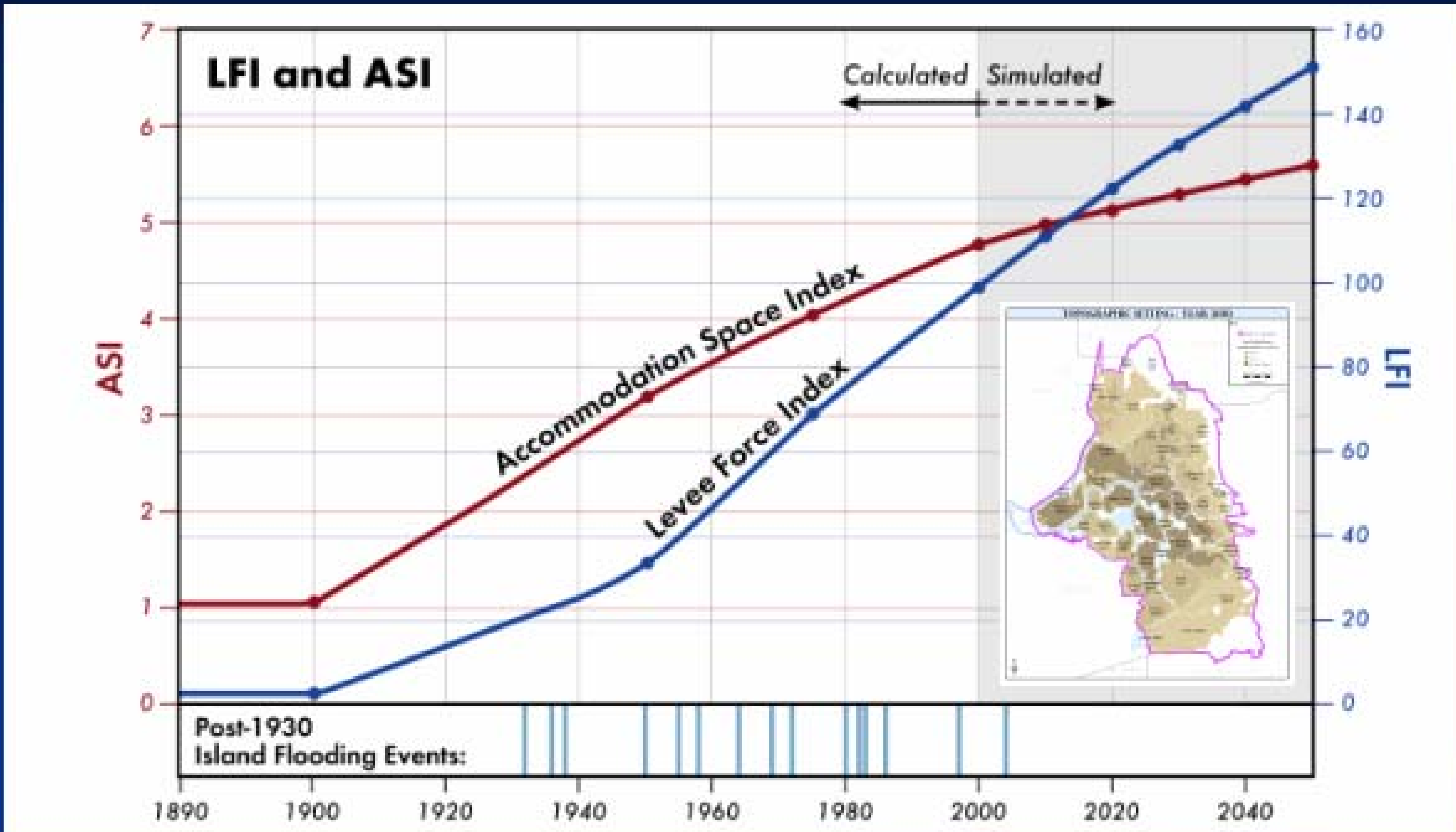
Anthropogenic
Accommodation Space
Antropogenic Accommodation Space
(million m3)
Calculated
Simulated
Central Delta
West Delta
South Delta
North Delta
East Delta
Post-1930
Island Flooding Events:
1,000
900
800
700
600
500
400
300
200
100
0
1880
1900
1920
1940
1960
1980
2000
2020
2040

- 2.5 Hydraulic Mining Eras worth of current space (Gilbert, 1917)
- 1500 years to restore existing space with current sediment loads (Schoellhamer, USGS), but
- Sea level rise alone creates almost twice the annual space that sediment is capable of filling
- Average daily increase of more than 27,000 m^3





Cumulative Levee Force
Calculated
Simulated
Force (10^{10} NT)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Central Delta
West Delta
North Delta
South Delta
East Delta
Post-1930
Island Flooding Events:
1800
1900
1920
1940
1960
1980
2000
2020
2040



LFI and ASI
Calculated
Simulated
Accommodation Space Index
Levee Force Index
ASI
LFI
Post-1930
Island Flooding Events:
0
1
2
3
4
5
6
7
0
20
40
60
80
100
120
140
160
1890
1900
1920
1940
1960
1980
2000
2020
2040


TOPOGRAPHIC SETTING - YEAR 2000
Key
Study Area Boundary
Land Subsidence, meters below sea level
Kilometers
YOLO
SACRAMENTO
SOLANO
CONTRA COSTA
ALAMEDA
SAN JOAQUIN
New Hope Tract
Ryer Island
Grand Island
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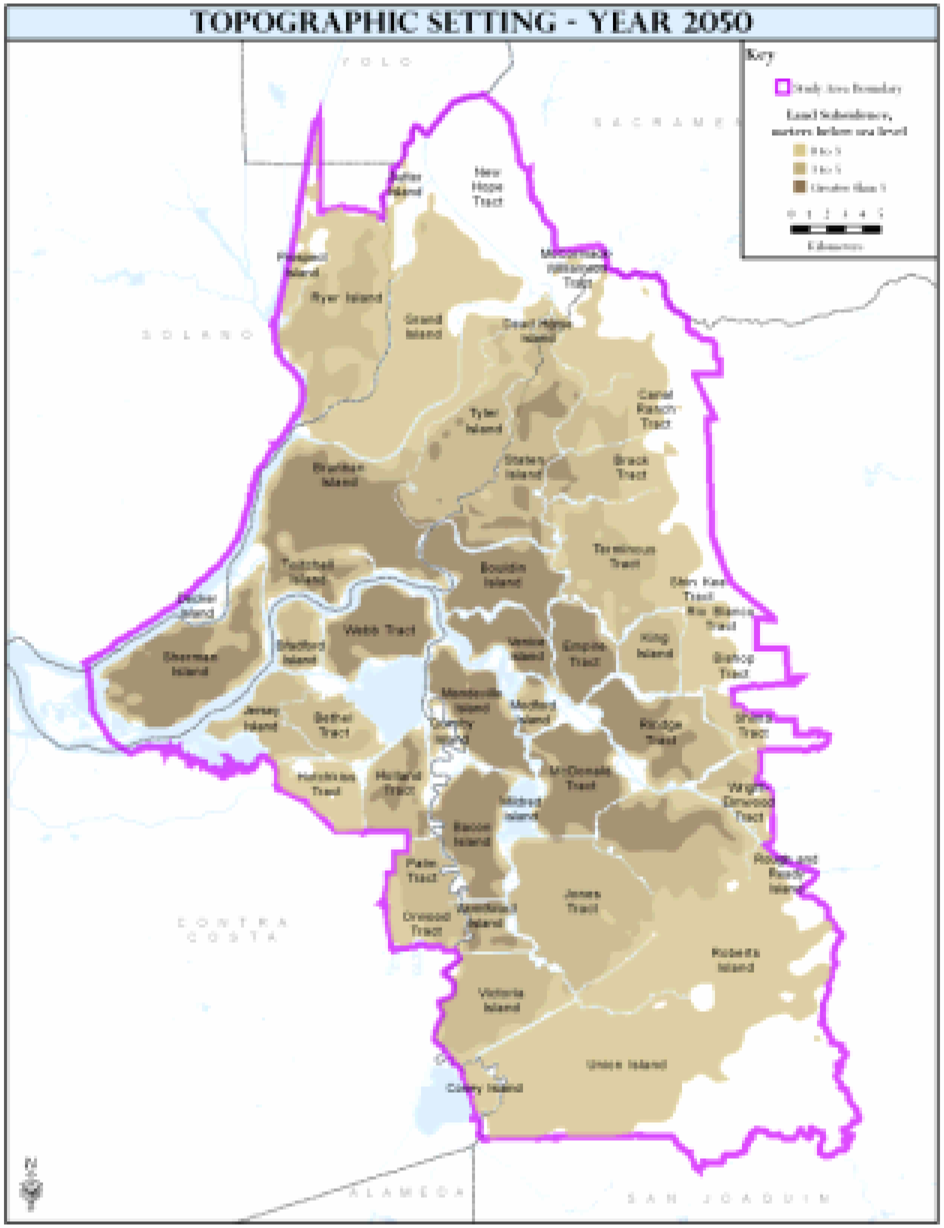
Palm Tract
Orwood Tract
Jones Tract
Roberts Island
Victoria Island
Union Island

TOPOGRAPHIC SETTING - YEAR 2050
Key
Study Area Boundary
Land Subsidence, meters below sea level
Kilometers
YOLO
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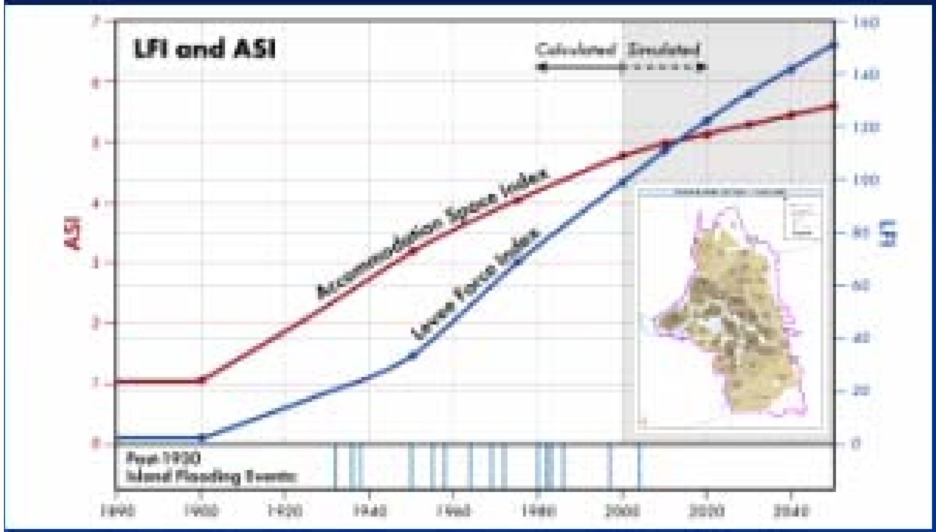
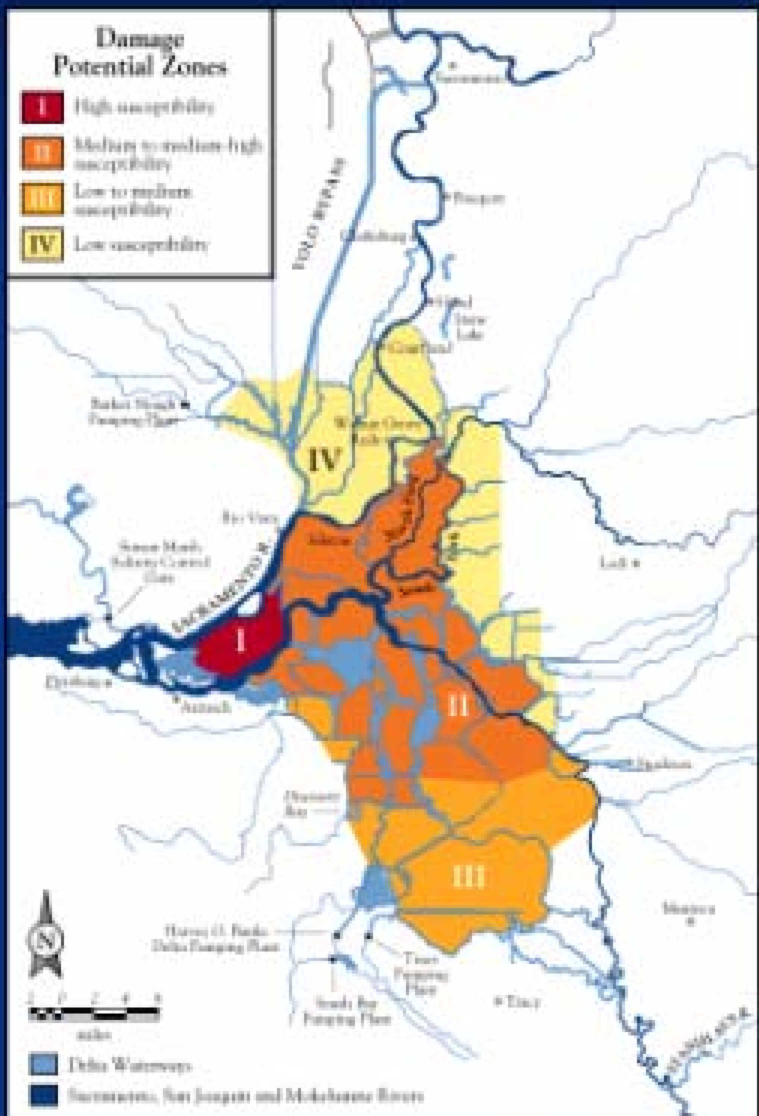
Union Island

Gradual Change: Tendencies and Trajectories



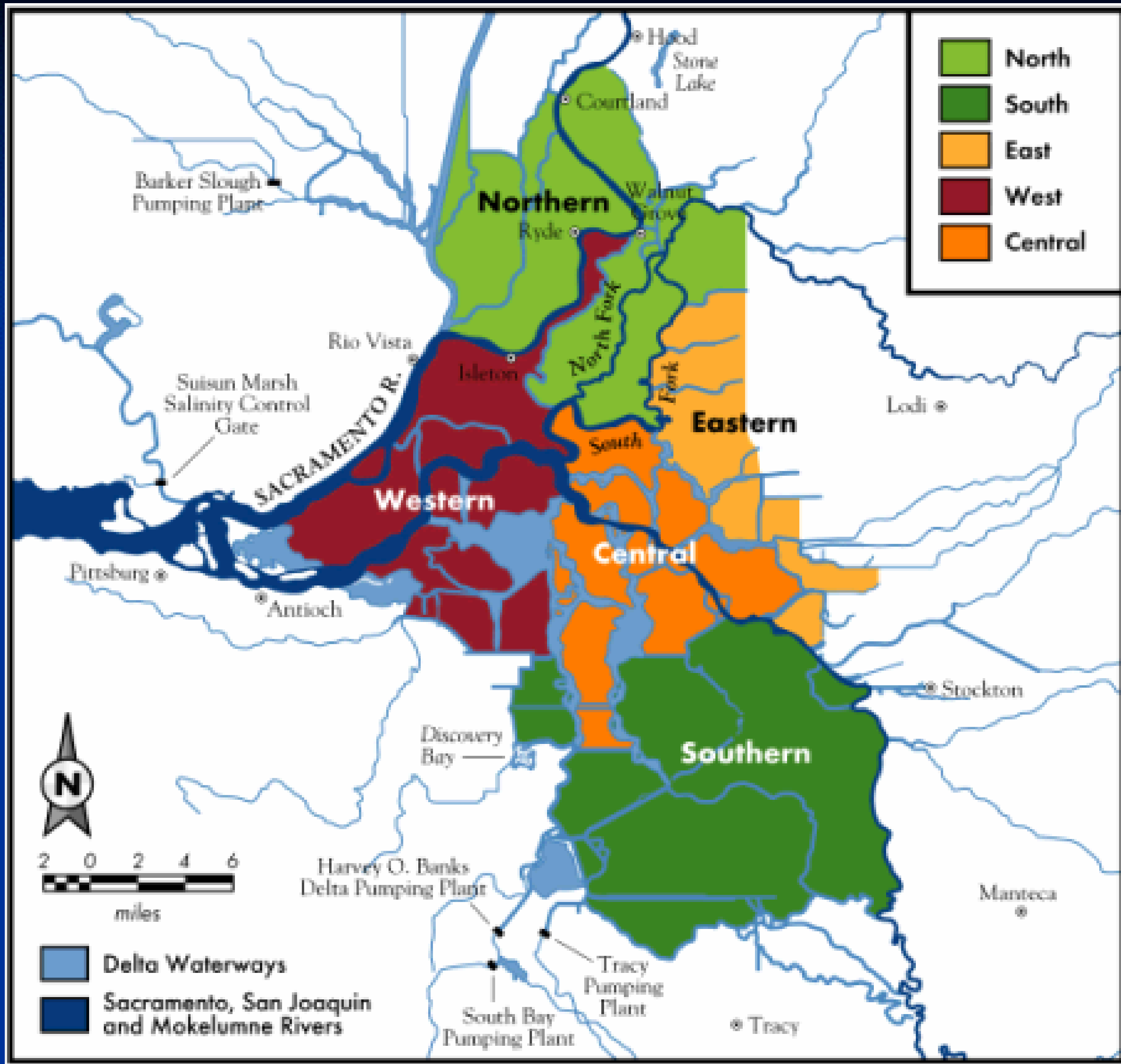
- Potential for and consequence of island flooding
- Backlog of $1B just to achieve PL-84 standards for current conditions
- Single-island failures cost $50-100M
- Unknown impacts on water supply, ecosystems

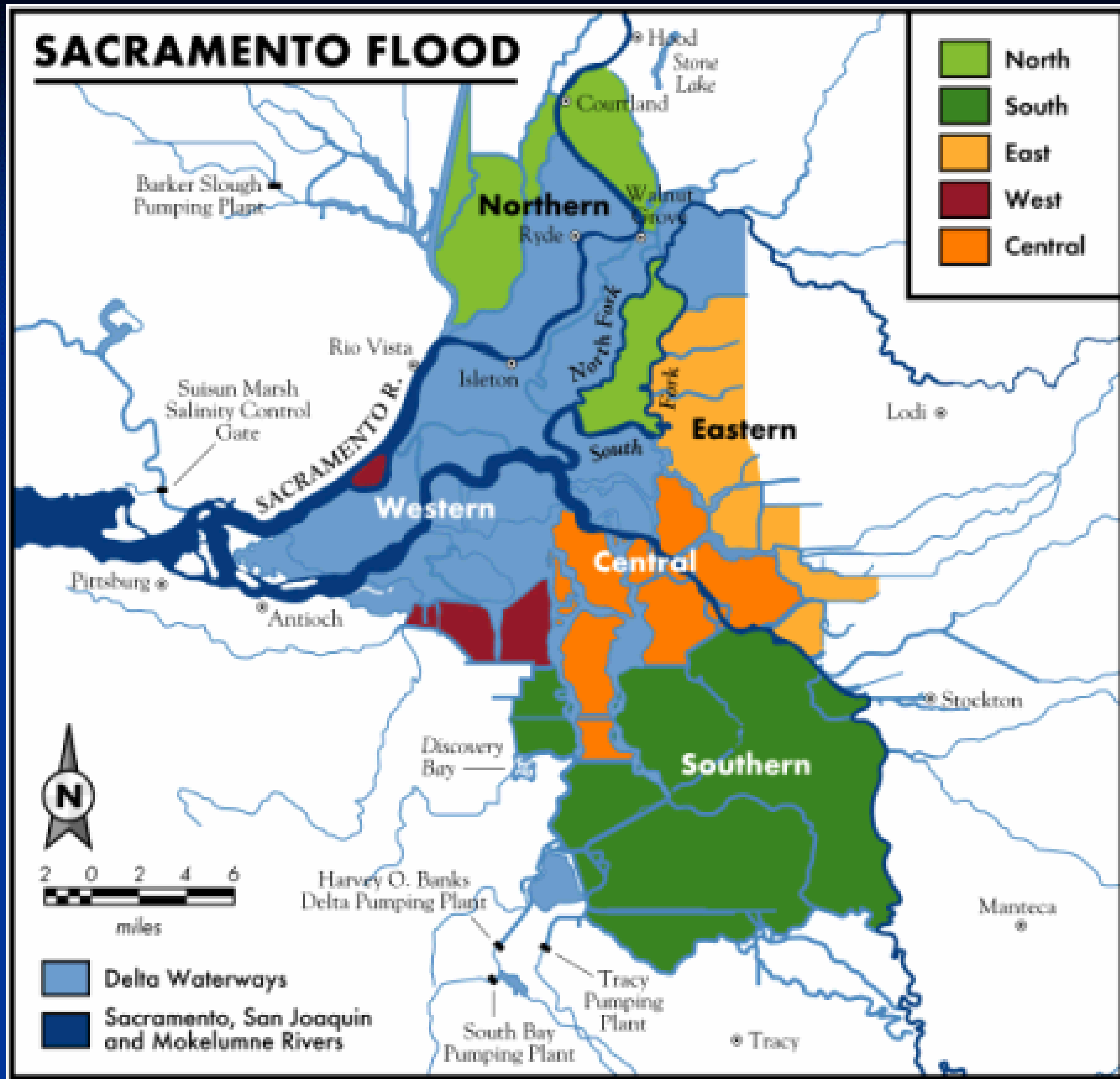
Abrupt Landscape Change



- Potential for significant island flooding during major floods or seismic events of >100-year recurrence interval (.01 exceedance probability)
- Widespread flooding of Delta islands will be a multi-year, multi-billion dollar disruption
- Abrupt change likely to result in permanent changes in Delta hydrology, water quality and ecosystems: a "new" Delta

Torres et al. (2000)


North
South
East
West
Central
Hood
Stone Lake
Courtland
Barker Slough Pumping Plant
Northern
Walnut Grove
Ryde
North Fork
Rio Vista
Isleton
Suisun Marsh Salinity Control Gate
SACRAMENTO R.
Lodi
Eastern
South
Fork
Western
Central
Pittsburg
Antioch
Stockton
Discovery Bay
Southern
N
2 0 2 4 6
miles
Harvey O. Banks Delta Pumping Plant
Manteca
Delta Waterways
Sacramento, San Joaquin and Mokelumne Rivers
Tracy Pumping Plant
South Bay Pumping Plant
Tracy


SACRAMENTO FLOOD
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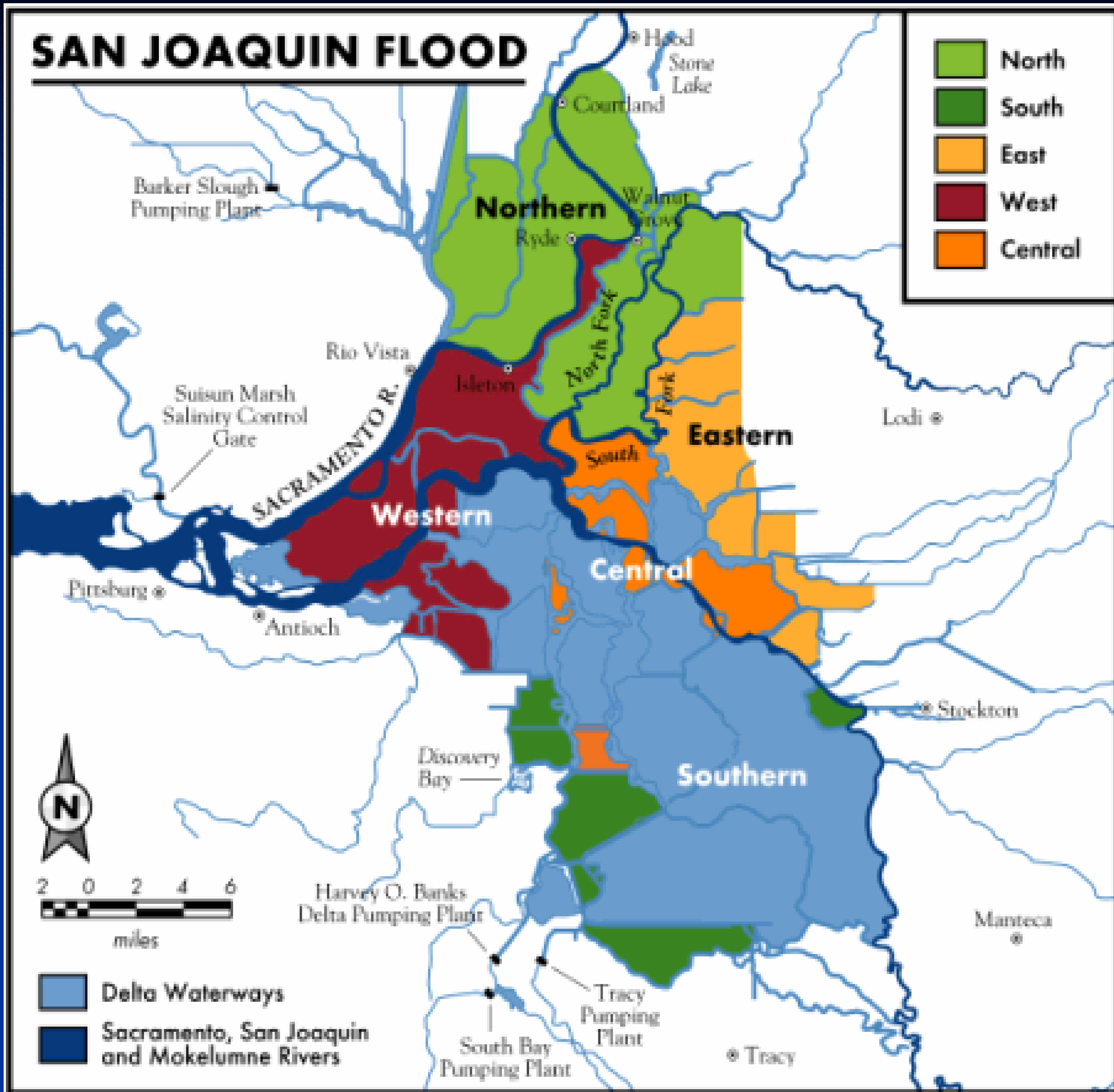
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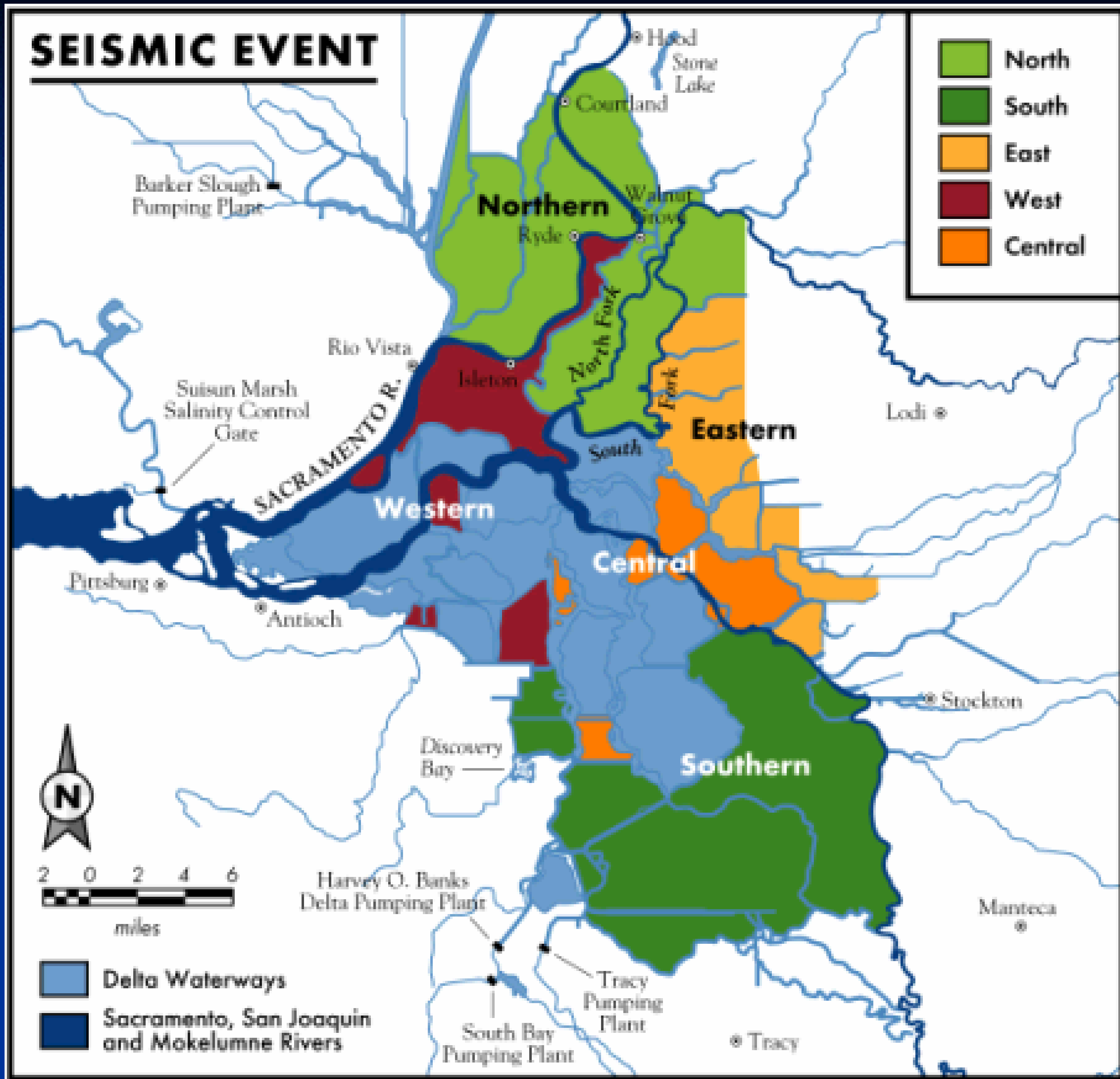

SEISMIC EVENT
North
South
East
West
Central
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SACRAMENTO FLOOD
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South
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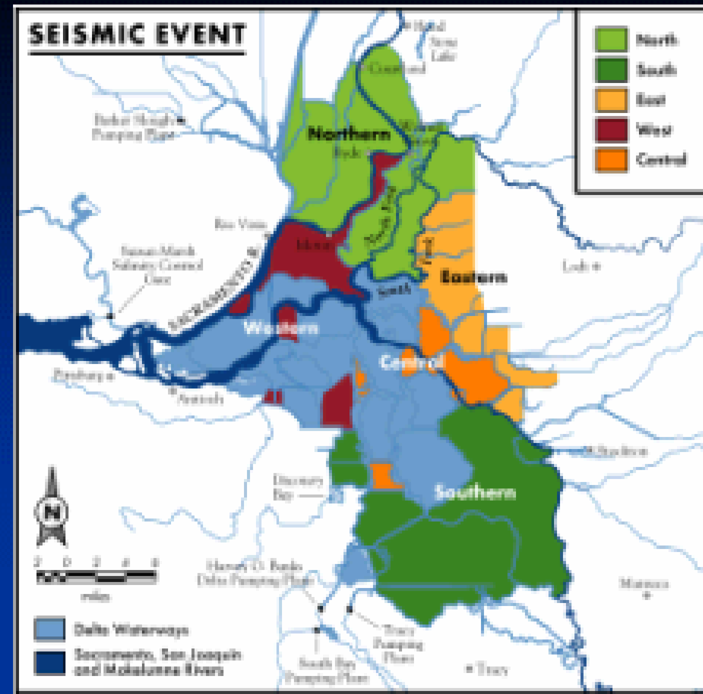
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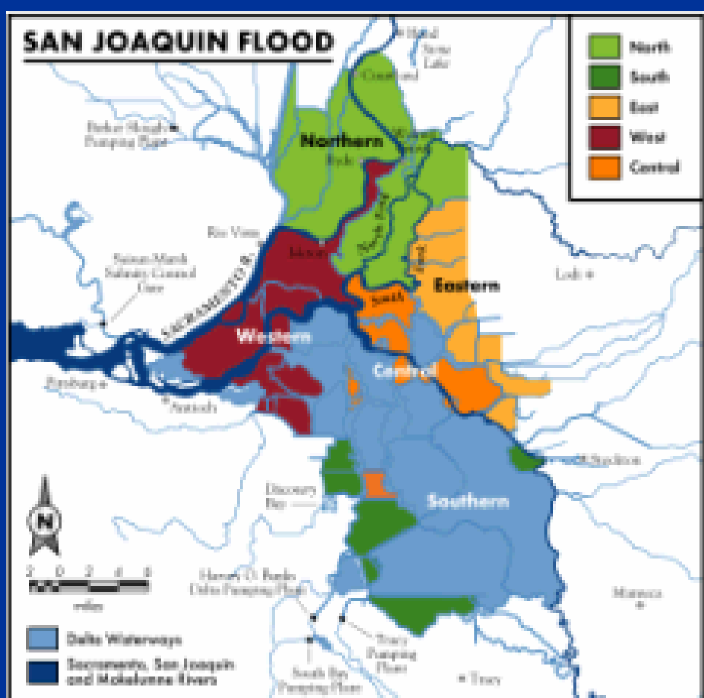
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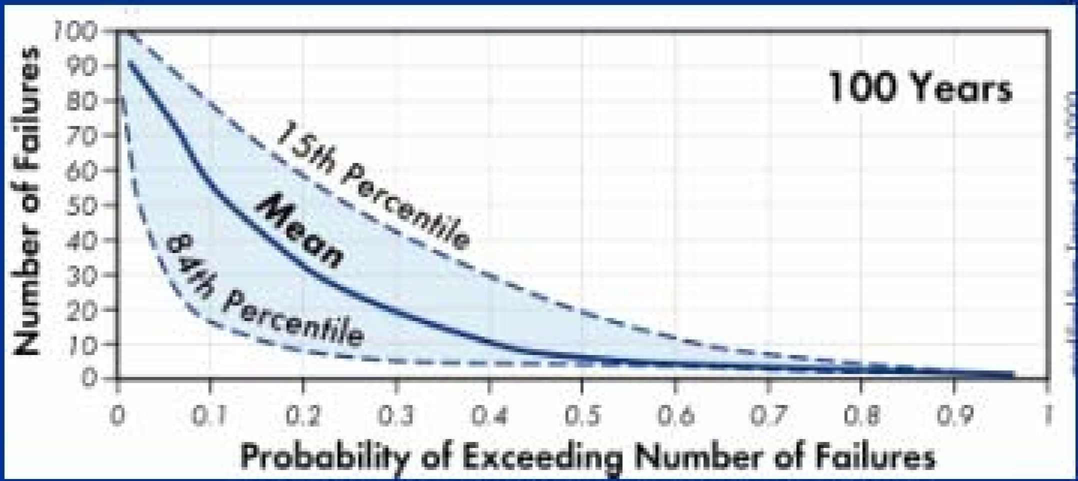
Sacramento, San Joaquin and Mokelumne Rivers


J. Punia

Abrupt Change in 50 Years: Remote or Real?

Some Probabilities

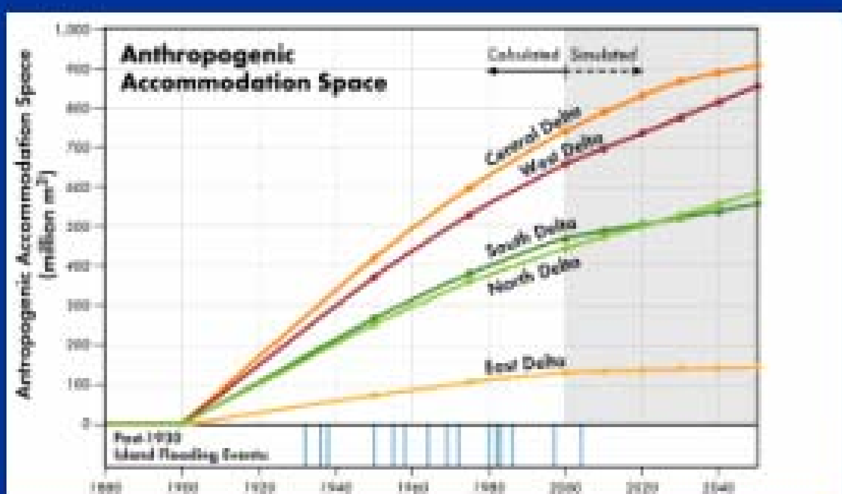
- 100-year earthquake = .40
- 100-year flood event = .40
- 100-year earthquake AND flood = .16
- 100-year earthquake OR flood = .64



Torres et al. (2000)

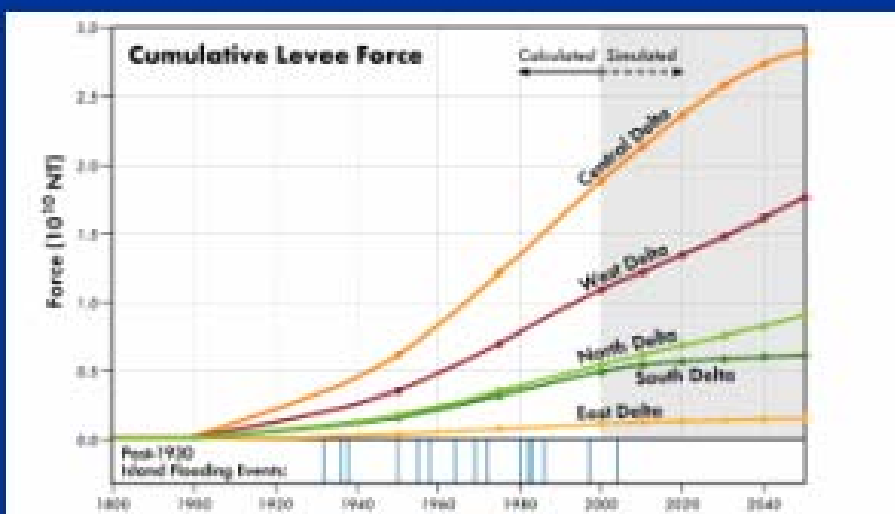
It is a 2-in-3 probability that abrupt change will occur in the Delta in the next 50 years

Conclusions

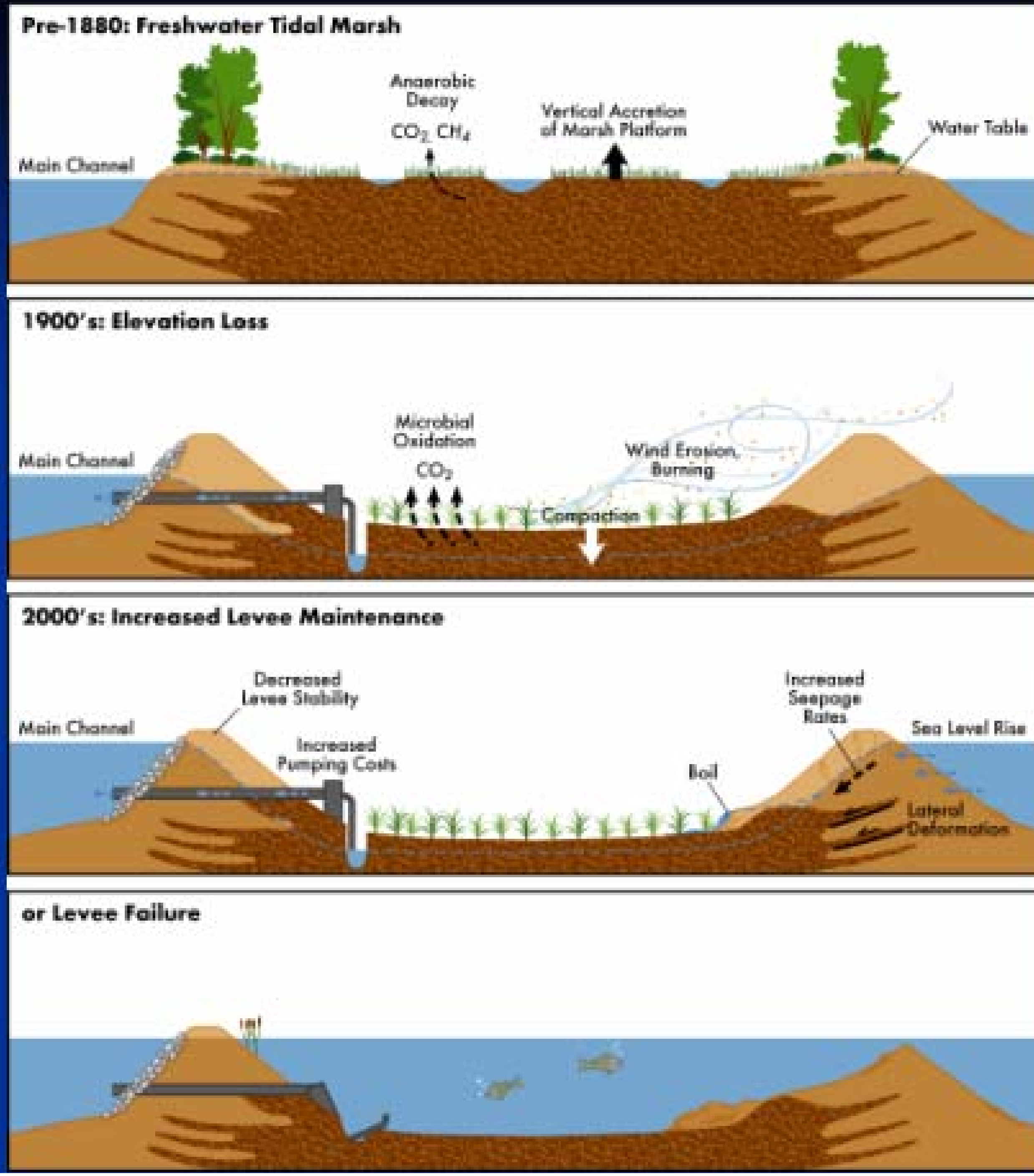


- Gradual change a certainty; abrupt change highly likely
- Estimates here are <u>conservative</u> and do not reflect cascade effects or embedded thresholds
- Left out impacts of regional climate change, including higher temps and larger floods

Conclusions



- Increasing levee failures, with significant but unknown impact
- No technologically or economically feasible method to restore elevations
- CALFED program planning remains predicated on a fixed, rather than dynamic landscape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